MONITORING PLAN

BLACK BAYOU HYDROLOGIC RESTORATION (C/S-27)

DATE: March 31, 2000

Project Description

The Black Bayou Hydrologic Restoration Project (C/S-27) is located approximately 18 miles west-northwest of Hackberry, Louisiana in northwest Cameron and southwest Calcasieu Parish. The project is bordered to the north by the Gulf Intracoastal Waterway (GIWW), to the south by Black Bayou, to the east by Gum Cove Ridge, and to the west by the Sabine River (figure 1). Total project area is approximately 25,529 acres and is comprised of approximately 6,516 acres of fresh/intermediate marsh, 7,353 acres of brackish marsh, and 11,660 acres of open water. Fresh/intermediate marshes are dominated by *Juncus roemerianus* (Black needlerush), *Phragmites australis* (Common reed), *Scirpus californicus* (California bullwhip), *Scirpus robustus* (Leafy three-square), *Spartina patens* (Marshhay cordgrass), and *Typha sp.* (Cattail). Brackish marshes are dominated by *J. roemerianus*, *P. australis*, *Scirpus olneyi* (Three-corner grass), *S. robustus*, *S. patens*, and *Typha sp*. Riparian hardwood forests are common along spoil banks of the Sabine River and the Gulf Intracoastal Waterway (GIWW). Major tree species are *Sapium sebiferum* (Chinese tallow tree), *Celtis laevigata* (sugar berry), and *Salix nigra* (black willow). The plant species list is based on the Wetland Value Assessment (NMFS 1996).

Several different soil types reflect the diversity of habitats found in the project area. Fresh/intermediate marsh areas are dominated by Ged mucky clay, Allemands muck, and Larose muck, while brackish marsh areas are comprised mostly of Gentilly muck and Banker muck, with smaller areas of Clovelly muck, and Creole mucky clay. The small intermixed coastal prairies are dominated by Morey silt loam and Mowata-Vidrine silt loam. Soils associated with the riparian hardwood forests areas, located along spoil banks of the Sabine River and the GIWW, consist of Udifluvents Series hydraulically excavated from soils in marshes during the construction and maintenance of navigable waterways (U.S. Department of Agriculture, Soil Conservation Service [USDA/NRCS] 1995).

In the early 1900's the marshes in the project area supported vegetation typical of fresh or very low salinity conditions (i.e. *Spartina patens, Typha sp.*, and *Scirpus sp.*). The introduction of water and sedimentation into the project area was influenced mainly by precipitation, local drainage, and wind and tide generated water exchange associated with Sabine Lake through overland flow and small, meandering bayous. Marsh elevation was maintained through vegetative biomass production which compensated for losses due to subsidence and sea level rise (USDA/NRCS 1997). More recently, wetlands in the Black Bayou area have suffered a loss of approximately 10,000 acres, 33% of the project area. Factors contributing to these losses include, but are not limited to, hydrological changes; reduced freshwater inflow from the uplands north of the GIWW; increased magnitude and duration of tidal fluctuations; increased salinities; higher water levels; excessive water exchange; and artificial water circulation patterns (NMFS 1996).

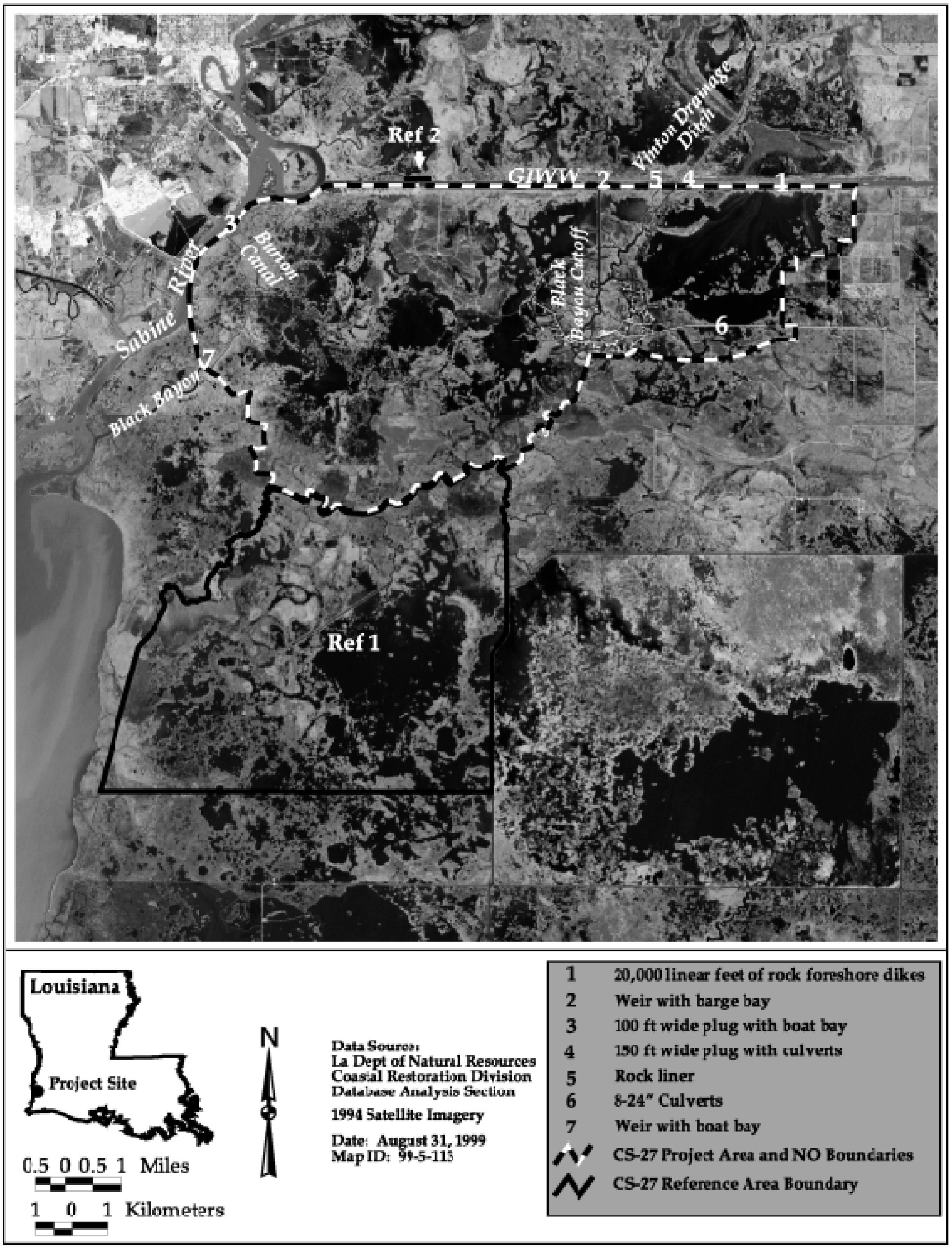

Figure 1. Black Bayou Hydrologic Restoration Project (C/S - 27) project area, reference area, and project structures.

Beginning in the late 1800's significant hydrologic changes effecting water level fluctuation and water circulation patterns occurred in the project area. Modifications to Calcasieu Pass such as the removal of the Calcasieu Pass oyster reef in 1876, increased the magnitude and duration of tidal fluctuations in both the lake and the surrounding marshes (LDNR 1993). Construction of the GIWW, North Line Canal, Central Line Canal, and South Line Canal established a hydrological connection between the Calcasieu and Sabine basins, allowing the saline waters of the Calcasieu Basin to encroach on the Sabine Basin. During ebb tide, these canals drain project area marshes simultaneously into both Sabine and Calcasieu Lakes. Water level fluctuations are also influenced by wind. A strong north wind can cause drastic de-watering of the marshes, while a strong sustained southerly wind can result in drastic increases in water levels blown in from the gulf. In addition "blowouts" (direct connections between a channel and an inland water body) often are formed by the water level drawdown effect and the wave wash from wakes created by passing boats and barges. "Blowouts" increase water circulation between the marsh and the GIWW, exposing fragile organic marsh soils to high energy and increased erosion (Good et al. 1995). The extensive system of navigation channels, natural drainage, bayous, oil exploration canals, trenasses, and "blowouts" have created several hydologic units inside the project area (figure 2) and have allowed increased water fluctuations and salinities to reach the interior of the marsh (USDA, 1991).

Marsh types and the associated vegetation in and around the project area also indicate that salinities have been increasing for the last 45 years. Prior to man-induced alterations, these marshes supported vegetation typical of fresh or very low salinity conditions. All of the project area was classified as fresh or low salinity (intermediate) marsh in 1949, except for the area adjacent to Sabine Lake and Sabine River just north of Black Bayou where brackish marsh conditions existed (Oneil 1949). Brackish marsh conditions in this area expanded north to the GIWW and eastward along Black Bayou to the Black Bayou Oil Field by 1968 (Chabreck 1968). Further expansion of high salinity marsh north and east of Black Bayou was documented in 1978 and again in 1988 (Chabreck 1978, 1988). By 1988, the majority of the project area was identified as brackish marsh with fresh marsh found only in the extreme northeast corner of the project area adjacent to the Gum Cove Ridge.

The Black Bayou Hydrologic Restoration Project includes structural and non-structural measures designed to allow freshwater from the GIWW near its confluence with the Vinton Drainage Canal into the wetlands south of the GIWW between the Sabine River, Gum Cove Ridge, and Black Bayou, and to create a hydrologic head that increases freshwater retention time and reduces salt water intrusion and tidal action in the Black Bayou watershed. Planned structural and non-structural measures and their intended functions are listed below. Proposed structure locations are identified on figure 1; proposed locations for vegetative plantings are identified on figure 2.

1) Repair breaches in the GIWW spoil bank west of the Gum Cove Ridge with approximately 20,000 linear ft. of rock foreshore dikes.

2) Construct a weir with a barge bay at the GIWW in the Black Bayou Cut Off Canal.

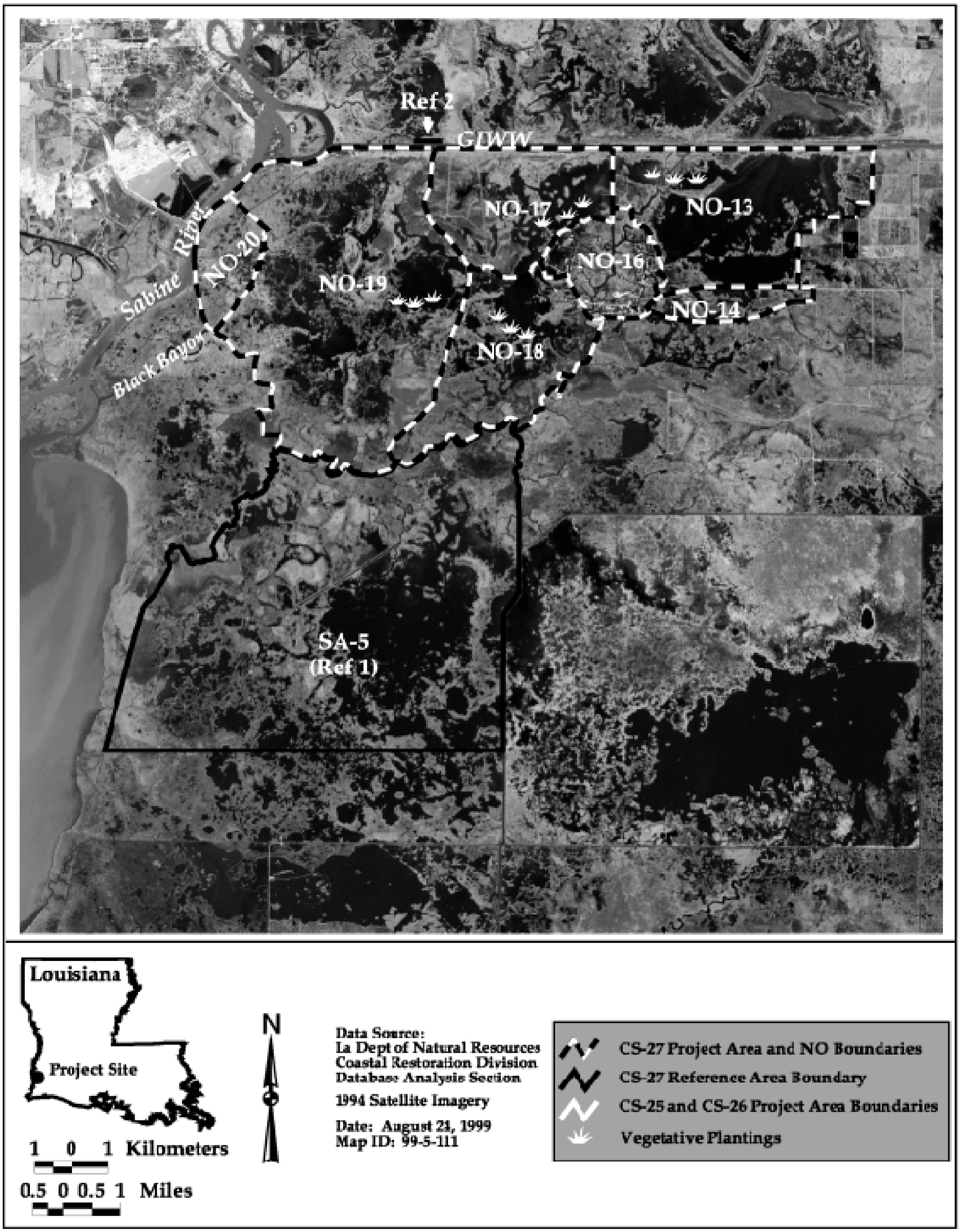

Figure 2. Black Bayou Hydrologic Restoration Project (C/S - 27) project area, reference areas, vegetative plantings, and Calcasieu-Sabine Hydrologic Units (USDA 1991).

3) Construct a 100 ft. wide plug with a 15 ft. boat bay at - 4 ft. bottom elevation in the Burton Canal at its intersection with the Sabine River.

4) Construct a 150 ft. wide plug with at least 4-48" culverts fitted with flapgates and screw gates in the Vinton Drainage Ditch.

5) Construct a 100 ft. wide plug in Black Bayou near its intersection with the GIWW.

6) Replace two collapsed culverts under the shell road, which serves as the NO-13 southern boundary, with as many as 8-36" culverts.

7) Construct a rock weir with a 15 ft. boat bay at - 3 ft. bottom elevation at the intersection of Blocks Creek with Black Bayou.

8) Vegetative plantings of approximately 55,000 linear ft. of bullwhip (*Scirpus califorinicus)* or other suitable vegetation in the large open water area within the NO-13 unit. Plants should be in one gallon trade containers with a minimum of 5 stems per container. Planting should be in two staggered rows on 5 ft. centers. An estimated 22,000 plants will be required.

9) Vegetative plantings of approximately 26,000 linear ft. of bullwhip (*Scirpus califorinicus)* or other suitable vegetation in the large open water area within the NO-17 unit. Plants should be in one gallon trade containers with a minimum of 5 stems per container. Planting should be in two staggered rows on 5 ft. centers. An estimated 10,400 plants will be required.

10) Vegetative plantings of approximately 26,000 linear ft. of bullwhip (*Scirpus califorinicus*) or other suitable vegetation in the large open water area within the NO-18 unit in a similar configuration to the plantings in unit NO-17. An estimated 10,400 plants will be required.

11) Vegetative plantings of approximately 26,000 linear ft. of bullwhip (*Scirpus califorinicus*) or other suitable vegetation in the large open water area within the NO-19 unit in a similar configuration to the plantings in unit NO-17. An estimated 10,400 plants will be required.

<u>Project Objectives</u>

1. Increase freshwater retention that reduces salt water intrusion in the project area wetlands.

2. Establish emergent wetland vegetation in shallow open water areas.

3. Protect emergent marsh in project area by reducing erosion along GIWW.

4. Increase occurrence of SAV in project area.

Specific Goals

1. Reduce mean salinities within the project area.

2. Increase the land to water ratio within the project area.

3. Reduce mean erosion rate of protected shoreline along GIWW.

4. Increase SAV in interior ponds within the project area.

Reference Area

Reference areas will be used to help separate project effects from spatial and temporal variability. Monitoring of both the project and reference areas provide a means to achieve statistically valid comparisons, and therefore, is the most effective way to evaluate project effectiveness. The main criteria for selecting reference areas are similarities in soil type, vegetation community, and hydrology of the project area. Two reference areas were selected for monitoring this project.

The area selected as reference area one (REF 1) is located south of the project area. It is bordered to the north by Black Bayou, to the west by the Sabine River, to the east by the Burton-Sutton Canal, and to the south by Central Canal (figure 1). The proposed reference has similar soils, vegetation, and is connected hydrologically by Black Bayou. However, the reference is not influenced by the GIWW and therefore may have limitations as a reference.

The area selected as reference area two (REF 2) is located north of the project area across the GIWW from the hydrologic unit NO-19. REF 2 is approximately 2000 ft. of shoreline along the GIWW that has similar soils, vegetation, and hydrology as the shoreline in the project area that will be protected by the rock dike.

The soils in both reference areas as well as in the project area are dominated by the Gentilly and Bancker association with inclusions of Clovelly and Ged. These soils are very fine montmorillontic, nonacid, thermic Typic Hydraquents formed by herbaceous plant remains and in clayey alluvium. They are common in brackish coastal marshes and are continuously ponded and frequently flooded (USDA/SCS 1995). Vegetation in the reference area and much of the project area is classified as brackish marsh and dominated by *Spartina patens*, *Scirpus robustus*, and *Scirpus olneyi*. Submerged aquatic vegetation (SAV) in the open water areas inside the project and in the reference area consist mainly of *Myriophyllum spicatum* (Eurasian water milfoil), *Ceratophyllum demersum* (Coontail), *Najas guadalupensis*, *Ruppia maritima*, and *Ottelia alismoides*. Hydrology of the project area and the reference areas have been influenced by several historical changes. Most significantly, the project area and REF 2 are influenced by the construction and operation of the GIWW (1940's) and the Calcasieu Ship Channel (1941). These areas also are influenced by the Black Bayou Cutoff Canal (1950's), numerous access canals, pipelines, and drill sites for oil and gas exploration, and the modification of natural drainage patterns resulting from dredge spoil banks associated with the construction. These factors have greatly influenced intrusion of saltwater from the Gulf of Mexico, water circulation patterns, and wind-driven wave erosion.

Monitoring Limitations

REF 1 is not directly influenced by the GIWW or Calcasieu Ship Channel and is primarily brackish marsh, whereas the project area has some areas of fresh/intermediate marsh.

Monitoring Elements

1. Aerial Photography- To document land to open-water ratios and land loss rates, color-infrared aerial photography (1:24,000 scale) will be obtained post construction, as an as built in the fall of 2000, and during the fall of 2004, 2009, and 2016. The photography will be processed by National Wetlands Research Center (NWRC) personnel using standard operating procedures documented in Steyer et al. (1995) for determining land-to-water ratios and corresponding acreage through GIS analysis.

2. Salinity- Salinity will be monitored at least monthly at permanent discrete sampling stations within the project and reference areas. The appropriate number of stations will be placed in each hydrologic unit (figure 2) to detect salinity changes. Salinity data will be used to characterize the spatial variation in salinity throughout the project area, and to determine if project area mean salinity is being reduced. Discrete salinities will be monitored in 1999 (preconstruction) and in 2000-2017 (post construction). In addition, water levels will be monitored on staff gauges at two permanent discrete sampling stations and inside and outside of project structures.

3. Vegetation Plantings- The species composition and relative abundance of all plant species and the percent survival of vegetative plantings will be determined in 3% of the vegetation plantings or in eighty sampling plots. Each sampling plot will consist of 16 plantings, from one or more rows depending on the planting design, with the sampling location determined by a random numbers table and marked with a labeled post. The sampling plots will be divided equally among the hydrologic units containing vegetative plantings. Planting survival will be determined as a percentage of the number of live plants to the number

initially planted (percent survival = no. plants/no. planted x 100), after Mendelssohn and Hester (1988) and Mendelssohn et al. (1991). Survival will be monitored after one growing season post construction in 2002 and in 2004 and 2006, or until the individual plantings become indistinguishable.

Percent cover estimates will be taken from the entire 16 plant plot to determine species composition and relative abundances for all species, including the plantings, using the Braun-Blanquet methodology (Mueller-Dombois and Ellenberg 1974).

4. Shoreline Change- To document shoreline movement along the southern shoreline of the GIWW, differential global positioning system (DGPS) surveys of unobstructed sections of the shoreline will be conducted at the vegetative edge. Surveys will be conducted in 2000 (preconstruction), immediately post construction, and in 2004, 2009, 2013, and 2016. A similar survey will be conducted concurrently along a 2000 ft (609.6 m) long section of reference area two (REF 2). DGPS shoreline positions will be mapped and used to measure shoreline erosion/growth rates. Shoreline rates will be used to calculate the total acres gained/lost and compared between the project and reference area.

5. Submersed Aquatic Vegetation- To document changes in the frequency of occurrence of SAV three transects per hydrologic unit and one transect in the reference area will be monitored using the rake method (Chabreck and Hoffpauir 1962). Transects will be established in open water areas in each hydrologic unit and separated by an equal distance. Each transect will have a minimum of 25 equally spaced sampling stations. At each station, aquatic vegetation will be sampled by dragging a garden rake on the pond bottom for one second. The presence of vegetation will be recorded to determine the frequency of aquatic plant occurrence (frequency = number of occurrences/25 x 100). When vegetation is present, the species present will be recorded in order to determine the frequencies of individual species (Nyman and Chabreck 1996). SAV will be monitored in the fall preceding construction, and postconstruction years 2002, 2004, 2006, 2009, 2011, 2013, 2016.

<u>Anticipated Statistical Analyses and Hypotheses</u>

The following paragraphs describe statistical tests that will be used to analyze data collected for each monitoring element included in this monitoring plan to evaluate the accomplishment of the project goals. The numbers to the left correspond to the monitoring elements described above. These are followed by statements of the project goals, and the hypotheses that will be used in the evaluation.

1) Aerial Photography: Descriptive and summary statistics on historical data (for 1956, 1978, and 1988) and data from color-infrared aerial photography collected pre- and post construction will be used, along with GIS interpretations of these data sets, to evaluate marsh to open water ratios and changes in the rate of marsh loss/gain in the project area.

Goal: Increase land to water ratio in the project area.

2) Salinity: Appropriate parametric and/or non parametric statistical tests will be used to test the following hypotheses. Salinities in the six different hydrologic units will be compared to salinities in the reference area where appropriate as determined by preconstruction and post construction data.

Goal: Reduce mean salinity levels within the project area.

Hypothesis[1]:

H_o: Mean salinity in the project area will not be lower post-construction than preconstruction.

H_a: Mean salinity in the project area will be lower post-construction than pre-construction.

Hypothesis[2]:

H_o: Mean salinity in the project area will not be lower than that in the reference area after construction.

H_a: Mean salinity in the project area will be lower than that in the reference area after construction.

3) Vegetative Plantings: The change in percent cover, species composition, and percent survival overtime will be analyzed using appropriate parametric and/or non parametric statistics, descriptive statistics, and life tables. The condition of the plantings will be used to determine if emergent wetland vegetation is established in open water areas inside the project area.

Goal: Establish emergent wetland vegetation in shallow open water areas.

4) Shoreline Change: Descriptive and summary statistics will be used to compare measured rates of shoreline change in the project and reference area between successive years. Also historical values for the area as well as data available from other surveys (i.e. USACE, USFWS, LDNR) will be

gathered to document and allow for appropriate parametric and/or non parametric statistical analysis of long term shoreline movement.

Goal: Reduce erosion rate of shoreline along the GIWW.

5) SAV: Appropriate parametric and/or non parametric statistical tests will be used to test the following hypotheses.

Goal: Increase the mean frequency of occurrence of SAV's in shallow open water within the project area.

Hypothesis[1]:

H_o: Mean frequency of occurrence of SAV within the project area will not be higher post-construction than pre-construction.

H_a: Mean frequency of occurrence of SAV within the project area will be higher post-construction that pre-construction.

Hypothesis[2]:

H_0: Mean frequency of occurrence of SAV will not be higher in project area than reference area after construction.

H_a: Mean frequency of occurrence of SAV will be higher in project area than reference area after construction.

Notes

1. Implementation schedule (tentative):

	Start construction	November 2000
	End construction	March 2001

2. NMFS Point of Contact: John Foret (318) 482-5915

3. DNR Project Manager: Herbert Juneau (318) 893-3643
DNR Monitoring Manager: Troy Mallach (318) 898-1758

4. The twenty year monitoring plan development and implementation budget for this project is $838,934. A progress report will be available in 2001 and comprehensive reports will be available in 2003, 2006, 2009, 2012, 2015, and 2020. These reports will describe the status and effectiveness of the project.

5. It was determined that monthly discrete salinity sampling at various locations would be preferable to collecting discrete and sonde data simultaneously to determine mean salinity. A Pearson Correlation of sonde and discrete salinity data from 1996, 1997, and 1998 at a similar project (Rycade CS/02) showed that monthly discrete salinity data and sonde monthly mean salinity data were highly correlated. In addition, daily mean salinity data from sondes did not differ significantly against monthly discrete data. To avoid data overlap, sondes will not be deployed.

References

Chabreck, R. H. and C. M. Hoffpauir 1962. The use of weirs in coastal marsh management in coastal Louisiana. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners 16:103-12.

Chabreck, R.H., T. Joanen, and A.W. Palmisano 1968. Vegetative type map of the Louisiana coastal marshes. Louisiana Wildlife and Fisheries Commission, Baton Rouge, LA. Scale 1:100,000.

Chabreck, R.H., and G. Linscombe 1978. Vegetative type map of the Louisiana coastal marshes. Louisiana Wildlife and Fisheries Commission, Baton Rouge, LA. Scale 1:100,000.

————. 1988. Vegetative type map of the Louisiana coastal marshes. Louisiana Wildlife and Fisheries Commission, Baton Rouge, LA. Scale 1:100,000.

Good, B., J. Buchtel, D. Meffert, J. Radford, K. Rhinehart, and R. Wilson 1995. Louisiana's Major Coastal Navigation Channels. Unpublished report. Baton Rouge: Louisiana Department of Natural Resources, Office of Coastal Management and Restoration. 57pp.

Louisiana Department of Natural Resources 1993. Wetland Value Assessment. Baton Rouge: Louisiana Department of Natural Resources, Coastal Restoration Division.

Mendelssohn, I.A. and M.W. Hester. 1984. Texaco USA Coastal Vegetation Project, Timbalier Island. Laboratory for Wetland Soils and Sediments, Center for Wetland Resources, Louisiana State University, Baton Rouge, LA. 128 pp.

Mendelssohn, I. A. and M. W. Hester 1988. Coastal vegetation project: Timbalier Island. Final Report submitted to Texaco, USA, New Orleans Division, New Orleans, LA. Agreement No. RC–84–01. 244 pp.

Nyman, J. A. and R. H. Chabreck 1996. Some effects of 30 years of weir management on coastal marsh aquatic vegetation and implications to waterfowl management. Gulf of Mexico Science 14:16-25.

NRCS. 1995. Soil survey of Vermilion Parish, Louisiana. U.S. Department of Agriculture (USDA), Natural Resources Conservation Service. 183+ pp.

NMFS. 1996. Wetland Value Assessment for Black Bayou Hydrologic Restoration Project (C/S-5a/12). U.S. Department of Commerce (USDC), National Marine Fisheries Service. 17 pp.

O'Neil, T. 1949. Map of The Southern Part of Louisiana Showing Vegetation Types of The Louisiana Marshes. Louisiana Wildlife and Fisheries Commission, New Orleans, LA.

Siegel, S. and N. J. Castellan. 1988. Nonparametric Statistics for Behavioral Sciences. 2d ed. New York: McGraw-Hill, Inc.

Steele, R. G. D. and J. H. Torrie 1980. Principles and Procedures of Statistics: a Biometrical Approach. New York: McGraw-Hill, Inc. 633 pp.

Steyer, G. D., R. C. Raynie, D. L. Steller, D. Fuller, and E. Swensen 1995. Quality management plan for Coastal Wetlands Planning, Protection, and Restoration Act monitoring program. Open-file series no. 95-01. Baton Rouge: Louisiana Department of Natural Resources, Coastal Restoration Division.

U. S. Department of Agriculture, Soil Conservation Service 1995. Soil survey of Cameron Parish, Louisiana. Publication No. 1995-386-441/00020. Washington, D.C.: U.S. Government Printing Office. 135 pp, 122 maps. Scale 1:20,000.

U. S. Department of Agriculture, Natural Resources Conservation Service 1997. Final Project Plan and Environmental Assessment for Sweet Lake/Willow Lake, C/S-11b, Cameron Parish, Louisiana. Alexandria: USDA/NRCS. 32 pp. plus appendices.

U.S. Department of Agriculture, Soil Conservation Service 1991. Calcasieu - Sabine Cooperative River Basin Study Report. Soil Conservation Service, Alexandria, Louisiana. 151pp. plus appendices.